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Mr. Oran Nicks, Director
Office of Lunar and Planetary Programs
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Subject: QUARTERLY REPORT OF WILLIAM H. JOHNSTON LABORATORIES, INC. on NASA CONTRACT NASw-987

INSTRUMENTATION FOR THE DETERMINATION OF THE LUNAR ATMOSPHERE

Gentlemen:

We are submitting this letter summarizing the activities on the above contract for the period July 13, 1964, to October 13, 1964.

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The major effort has been expended on the design modifications in the coincidence mass spectrometer for operation in an ultra-high vacuum system. Considerable attention has also been given to the design of the vacuum system and the bake-out facility. A prototype coincidence mass spectrometer has been used in preliminary measurements to aid in the resolution of some of the design problems.

author

The design of the ultra-high vacuum coincidence mass spectrometer system has been completed. All of the purchased items have been ordered and parts to be fabricated are under construction. The vacuum housing and components of the coincidence mass spectrometer have been designed to allow baking

of the assembled system to 450°C. The ionization region of the coincidence mass spectrometer was modified from previous designs to improve the pumping efficiency for this region. Provisions have been made for effectively isolating the region containing the hot filament from the ionization region of the coincidence mass spectrometer.

The vacuum system constructed for this work uses a C. V. C. ultra-high vacuum 4" oil diffusion pump and water cooled chevron baffle in conjunction with a Granville-Phillips 4" liquid nitrogen cold trap. These components are of stainless steel construction and metal gasketing is used throughout. The pumping speed of this system is constant at about 200 l/sec down to a pressure of 10^{-9} torr. The ultimate vacuum after bakeout should be 5×10^{-10} torr or better.

The experimental measurements using a prototype coincidence mass spectrometer were aimed primarily at obtaining additional data pertinent to operating in ultra-high vacuum. These measurements indicated the need for further reduction in the number of stray electrons reaching the electron detector. Methods for reducing the number of stray electrons were studied by measuring the changes in stray electron rate with changes in the geometry of the electron gun and electron trap in the prototype coincidence mass spectrometer. These results were used in finalizing the design modifications of the coincidence mass spectrometer for operation in ultra-high vacuum.

The experimental studies which provided the data for the engineering modifications also led to several interesting scientific discoveries. In the original configuration of the coincidence mass

spectrometer each analyzed ion received approximately 500 volts acceleration in the ion lens and an additional 3000 volts after the drift region. This was done to lengthen the drift times and to provide sufficient energy to trigger the ion detector. It was discovered and proven that small satellite noise peaks which were associated with the primary specie peaks in the mass spectrum were due to charge exchange in the drift tube. For example, under the conditions stated, the charge exchange reaction with a specie such as nitrogen was,

$$N_2^+ \text{ (500 v)} + N_2 \text{ (thermal)} \longrightarrow N_2 \text{ (500 v)} + N_2^+ \text{ (thermal)}$$

Interestingly, the 500 volt neutral N_2 triggered the detector; since it had not received the post drift acceleration, it arrived late and constituted the satellite peak. This effect was eliminated by discarding post drift acceleration. Proof of this effect was obtained in the present studies. We are unaware of any published evidence for the detection of neutrals at 500 volts by a copper beryllium dynode electron multiplier. At this voltage the corresponding ion is not detected.

Some of the data obtained on this effect is shown in Figure 1. In this experiment a mixture of nitrogen and argon was injected into the coincidence mass spectrometer. The pressure in the vacuum chamber was maintained at the unusually high value of 10^{-4} torr to enhance the probability of charge exchange in the drift tube. The ion energy on entering the drift tube was determined by the drift tube potential, which for this experiment was maintained at 500 volts negative. After the ions drifted through the field free drift tube, they were given an additional acceleration by the potential difference between the drift tube and the first dynode of the ion detector multiplier. The intensity of the charged and neutral peaks

were measured as a function of first dynode potential with the necessary positive voltage applied to the opposite end of the multiplier voltage divider to keep the total multiplier voltage constant at 4000 volts. These data are shown in Figure 1. The neutrals formed by charge exchange of the 500 ev ions in the drift tube are unaffected by the post drift tube acceleration and their intensity is found to be constant. On the other hand, the ion intensity is essentially zero at 500 ev total energy and the measured intensity increases linearly with increasing total energy. It is well known that the efficiency of electron multipliers is quite low for ions with energies of 500 ev or less and that the efficiency increases rapidly with energy; however, the efficiency for 500 ev neutrals is rather surprising.

At the request of Mr. Donald Easter a presentation was made concerning this program to the Lunar Atmosphere Team of the Apollo Science Program in Houston early in September. As a result of this meeting Mr. Dallas Evans of Manned Space Craft Center has scheduled a visit to Baltimore for December 9, 1964. Although the ultra-high vacuum bakeout facility will not be completed as of that date, a demonstration of the operation of the coincidence mass spectrometer will be made to this Team and the status, theoretical and experimental, of this program will be discussed with them.

If you require any further information please do not hesitate to call upon us.

Sincerely yours,

Wm. H. JOHNSTON LABORATORIES, INC.

Wm. H. Johnston
Director

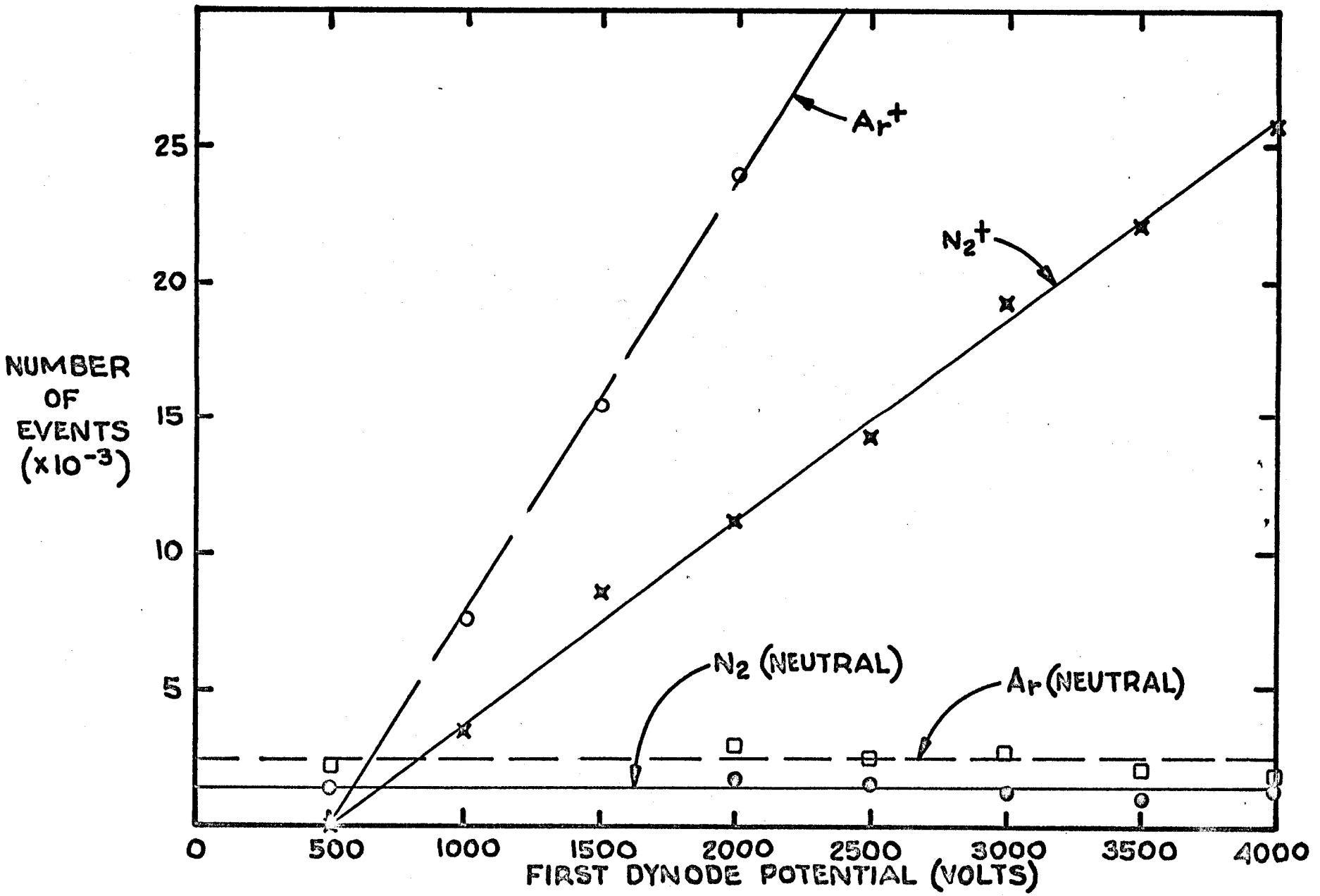

Figure 1. Intensities of argon and nitrogen ions and neutrals as functions of the first dynode potential. These measurements were made at a pressure of 10^{-4} torr in the coincidence mass spectrometer. The ion accelerating voltage before the drift space was 500 volts.